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*Indian Standard*

# METHOD FOR DETERMINATION OF THERMAL RESISTANCE OF TEXTILE FABRICS

## GUARDED HOT PLATE METHOD

(Incorporating Amendment No. 1)

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BUREAU OF INDIAN STANDARDS
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

Price Group 2

# *Indian Standard*

# METHOD FOR DETERMINATION OF THERMAL RESISTANCE OF TEXTILE FABRICS

## GUARDED HOT PLATE METHOD

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# *Indian Standard*

# METHOD FOR DETERMINATION OF THERMAL RESISTANCE OF TEXTILE FABRICS

## GUARDED HOT PLATE METHOD

## 0. FOREWORD

**0.1** This Indian Standard was adopted by the Indian Standards Institution on 15 July 1965, after the draft finalized by the Textile Standards Sectional Committee had been approved by the Textile Division Council.

**0.2** The thermal resistance of a fabric is one of the important factors which influence the effectiveness of the fabric in keeping the body comfortable. This factor includes the thermal conductivity of the fabric. This standard prescribes a method for determination of thermal resistance.

**0.3** The Sectional Committee derived considerable assistance from 'The transmission of heat through textile fabrics' by F. T. Peirce and W. H. Rees published in Shirley Institute Memoirs, Vol XVIII and Vol XIX.

**0.4** This edition 1.1 incorporates Amendment No. 1 (April 2000). Side bar indicates modification of the text as the result of incorporation of the amendment.

**0.5** In reporting the result of a test made in accordance with this standard, if the final value, observed or calculated, is to be rounded off, it shall be done in accordance with IS : 2-1960*.

## 1. SCOPE

**1.1** This standard prescribes a method for determining the thermal resistance of textile fabrics.

**1.2** This standard is applicable to all types of textile fabrics including blankets, shawls, etc, irrespective of their composition (that is, irrespective of whether the fabric is made of wool, silk, nylon or a blend of two or more textile fibres) and their construction (that is, irrespective of whether the material is a woven fabric, a knitted fabric or a felted material).

## 2. TERMINOLOGY

**2.0** For the purpose of this standard, the following definitions shall apply.

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*Rules for rounding off numerical values ( *revised* ).

**2.1 Thermal Resistance** — The resistance offered by the fabric to the flow of heat when its two faces are at different temperatures, as denoted by the ratio of the temperature difference to the rate of flow of heat per unit area, the flow being normal to the surfaces.

NOTE — Since surface temperatures of fabrics are difficult to measure precisely, the temperature difference between the hot plate on which the fabric is put during test and that of air 20 mm above the other surface of the fabric will be taken to assess the thermal resistance.

**2.2 Tog** — The unit of thermal resistance. This is the resistance that will maintain a difference of 10 deg between two parallel isothermal plates with a heat flux of one watt per square decimetre.

NOTE 1 — By adopting this unit the thermal resistance of any fabric could be conveniently described by a range of small integers (1 to 10). For example, a light summer suiting has a thermal resistance of 1 tog and 10 togs represent the thickest clothing that could be worn.

NOTE 2 — Still air has a thermal resistance of 0.4 togs approximately.

## 3. SAMPLING

3.1 Sample to determine conformity of a lot to this standard shall be selected so as to be representative of the lot.

## 4. APPARATUS

4.1 The apparatus shall consist of:

a) hot-plate assembly,

b) heaters, and

c) devices for measuring the surface temperature of hot-plates.

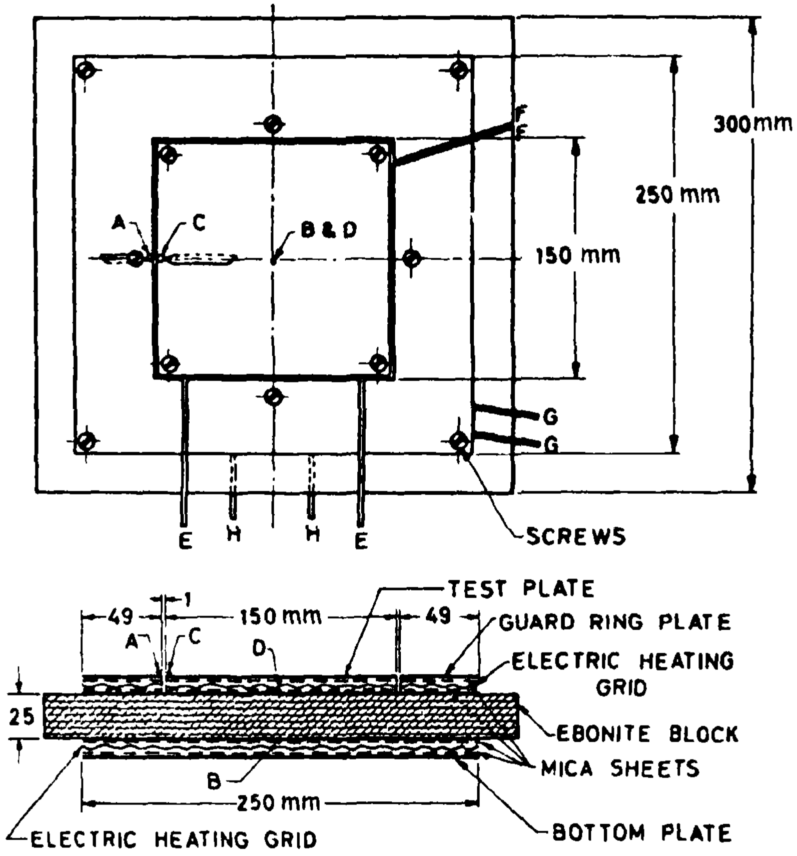
4.1.1 *Hot-Plate Assembly* — The hot-plate assembly ( *see* Fig. 1 ) shall consist of the test plate, guard ring plate and the bottom plate which is intended to prevent a downward loss of heat from the other two plates. All the plates shall be made from thin (1.5 to 2 mm thick) sheets of highly conductive metal like copper. The surface of the metal shall be finished to a true plane and lacquered to give a high emissivity. Each of these shall be electrically heated and maintained at a constant temperature by separate heating grids.

4.1.1.1 The hot-plate assembly shall be housed in an air-tight wooden box of one metre cube provided with:

a) thermostatic arrangement to maintain a constant temperature with an accuracy of ± 0.5 deg C at about 8 to 10 deg below the bottom plate temperature,

b) arrangements to maintain a constant humidity within the box and to measure it,

c) arrangements to maintain the velocity of air at 1 m/s,



*A* — Guard ring plate thermo-couple

*B* — Bottom plate thermo-couple

*C*, *D* — Test plate thermo-couples

*EE* — Test plate heater terminals

*FF* — Differential couple across the test-plate & guard ring plate

*GG* — Guard ring plate heater terminals

*HH* — Bottom plate heater terminals

FIG. 1 HOT-PLATE ASSEMBLY

d) suitable means to direct the air current so as to impinge on the specimen at an angle of 45°, and

e) thermocouples suspended inside the box so that the measuring junction is exposed to the air at 20 mm above the test specimen to measure the temperature of the ambient air inside the box.

4.1.2 *Heaters* — Each of the heating grids used for maintaining the plates at constant temperature shall be provided with separate electric circuit with a control to adjust the current and meters to measure the current and the voltage to an accuracy of ± 1 percent. The current may be alternating or direct. The heating grids shall be insulated from the plates by means of thin sheets of mica.

4.1.3 *Devices for Measuring Surface Temperature* — The surface temperature of the hot-plates shall be measured by fine wire thermocouples. The difference in temperature between the test plate and the guard ring plate shall be measured by a differential thermocouple.

NOTE — Calibrated thermocouples, such as copper-constantan or copper-advance, may be used.

4.1.3.1 Potentiometer having high sensitivity of at least 5 microvolts shall be used for measuring thermal electromotive force and other voltages. The wattage of the central heater may be measured.

## 5. PREPARATION OF TEST SPECIMEN

5.1 Cut out from each piece constituting the test sample a test specimen ( *see* Note ) of 300 × 300 mm such that two adjacent sides are parallel to the direction of warp and weft respectively. Cut out at least 3 more test specimens so that the total number of test specimens is at least 4.

NOTE — In case the sample is a woven fabric, cut out the test specimen from a distance of at least 150 mm away from the selvedges.

## 6. PROCEDURE

6.1 Switch on the electrical circuit of the three heaters and adjust the current so as to maintain the temperature of the three plates at 33°C to 36°C.

NOTE 1 — All the plates are to be kept at the same temperature so that all the electrical energy supplied to the test plate is lost as heat energy only in a direction normal to the fabric under test.

NOTE 2 — In order to simulate the actual condition of sample when in use, the temperature has been prescribed as 33°C to 36°C which is assumed as the typical human skin temperature.

6.2 Adjust the temperature of the air inside the wooden box to remain at a constant value of 25°C and the air circulating inside the box at a velocity of 1 m/s and the humidity at a constant value.

**6.3** Transfer the test specimen to the test plate. If the test specimen is pre-heated ( *see* Note ), this transfer should be effected very quickly. By means of suitable clamps, keep the test specimen in contact with the test plate and guard ring plate at zero tension and close the wooden box.

NOTE — At low temperature when testing takes more time, pre-heating may be done, if necessary.

**6.4** Read the temperature of the test plate, guard-ring plate and the bottom plate at half-hour intervals until the three temperatures show identical and constant values ( *see* Note ) and the differential thermocouple gives zero reading. Take again at least four more readings at half-hour intervals. Note down this constant temperature ( $T_1$ ). Note down the current in amperes ( $C$ ) and the voltage ( $V$ ) as read from the ammeter and voltmeter respectively, of the heater circuit of the test plate. By means of the thermocouple kept at 500 mm above the test specimen, measure the ambient air temperature ( $T_2$ ) inside the box.

NOTE — If the difference in temperature between the successive readings does not exceed 0.1 deg, the temperature shall be held to be constant.

**6.5** Calculate, correct to two places of decimals, the thermal resistance in togs of the test specimen as under:

$$\text{Thermal resistance, in togs, of test specimen} = a \times \frac{(T_1 - T_2)}{10} \times \frac{1}{C \times V}$$

where

$a$ = area of the fabric in dm$^2$;

$T_1$ = temperature of test plate in °C;

$T_2$ = temperature of ambient air inside the box in °C;

$C$ = current, in amperes, to maintain the test plate at $T_1$ °C; and

$V$ = voltage required to maintain the test plate at $T_1$ °C.

**6.6** Repeat the test with the remaining test specimens and calculate the mean of the values. Report it as the thermal resistance of the fabric in the lot. Report also the relative humidity inside the box.

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